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25 June 1982

USSR REPORT  
PHYSICS AND MATHEMATICS

No. 78

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## ACOUSTICS

UDC 534.86

### NEW CLASS OF ELECTROACOUSTIC TRANSDUCERS: GASEOUS TRANSDUCERS

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 2, Mar-Apr 82  
(manuscript received 21 Nov 80) pp 268-270

OSTROUMOV, G. A., Leningrad State University imeni A. A. Zhdanov

[Abstract] Gaseous electroacoustic transducers, unlike solid ones, have no rigid surface and an acoustic impedance close to that of the ambient medium. The performance of these class-II transducers (solid transducers are class-I) can be described by a nonhomogeneous wave equation with homogeneous (impedance) boundary conditions. The operating principle of such a device is essentially based on corona discharge from a needle point. The radiation pattern here is that of a "tripole", a superposition of an isotropic monopole and a dipole with a quarter-period phase difference. This phenomenon is explained by action of ponderomotive forces in the electric field and generation of an electric wind. A practical application is suggested: a circular ring of insulating material with many uniformly spaced holes drilled through obliquely, all at the same angle to the radius, and a needle inserted into each from the inside projecting into the inner cavity and forming a uniform circular microphone array with an air diaphragm. Figure 1, references 3: 2 Russian, 1 Western.

[156-2415]

UDC 354.24

### REFLECTION OF OBLIQUELY INCIDENT SURFACE ACOUSTIC WAVES BY PERIODIC SURFACE INHOMOGENEITY

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 2, Mar-Apr 82  
(manuscript received 5 Feb 81) pp 228-231

KALININ, V. A. and SHTYKOV, V. V., Moscow Institute of Power Engineering

[Abstract] Reflection of an obliquely incident plane Rayleigh surface acoustic wave by a periodic grating of infinitely long isotropic strips

is considered, under conditions of nearly cophased reflection and assuming a sinusoidal surface profile. The reflection coefficient is calculated by the method of associated waves and the results are compared with experimental data on reflection of such waves by metal (copper, aluminum, gold) strips in an acoustic waveguide made of piezoceramic material (quartz). Figures 2, table 1, references 9: 4 Russian, 5 Western.

[156-2415]

UDC 534.26

#### REFLECTION AND TRANSMISSION OF WAVES IN ASYMMETRICALLY JOINED BEAMS

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 2, Mar-Apr 82  
(manuscript received 14 Jan 81) pp 201-206

ZHIVAYEV, V. Ya., Institute of Acoustics imeni N. A. Andreyev,  
USSR Academy of Sciences

[Abstract] Two strips segments of the same material and of the same thickness but of different uniform widths are rigidly joined with their median surface matching but their longitudinal axes offset parallel. Reflection and transmission of flexural and torsional waves in these strips, as well as attendant partial transformation of one kind of wave to another at the joint, are analyzed on the basis of the corresponding system of fourth-order partial differential equations for vibrating beams. The solution is used to calculate the energy coefficients of reflection and transmission as well as the frequency characteristics of the respective energy fluxes. Symmetrically joined unequally wide strips and a continuous beam of uniform width are treated as two extreme special cases. The author thanks V. V. Tyutenko for formulating the problem and discussing the results. Figures 3, references 1 Russian.

[156-2415]

UDC 534.29:535.37

#### HYDRODYNAMIC EFFECTS DURING OPTICAL BREAKDOWN OF FLUID

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 2, Mar-Apr 82  
(manuscript received 22 Jan 81) pp 192-200

DUNINA, T. A., YEGEREV, S. V., LYAMSHEV, L. M., NAUGOL'NYKH, K. A. and PASHIN, A. Ye., Institute of Acoustics imeni N. A. Andreyev, USSR Academy of Sciences

[Abstract] An experimental study was made of acoustic emission during optical breakdown of distilled water and tap water by a laser spark. A spark in water was produced by a 60 ns pulse from a ruby laser, after focusing by a lens and transmission through neutral light filters for

regulation of the pulse energy over the 10-300 mJ range. The time characteristics of such a pulse were measured with a coaxial photocell and beam splitter. The dynamics of microcavity formation and conversion of optical to acoustic energy are analyzed on the basis of a very inexact model, namely expansion of a spherical bubble with a homogeneous plasma, and numerical integration of the corresponding thermodynamic and hydrodynamic equations for the two extreme cases: array of isolated plasma bubbles and fully developed plasma arc. Calculations are based on the Kirkwood-Bethe approximation for the transsonic process mode above the threshold. Rough estimates of the energy conversion efficiency are also made on the basis of approximate relations not requiring numerical integration. Figures 6, references 14: 11 Russian, 3 Western.

[156-2415]

#### PROPAGATION OF SOUND PULSES THROUGH METAL WITH OPEN FERMI SURFACE

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 82, No 3, Mar 82 (manuscript received 20 Sep 81) pp 862-871

GOKHFEL'D, V. M. and PESCHANSKIY, V. G., Donetsk Physico-Technical Institute, UkrSSR Academy of Sciences

[Abstract] Propagation of a sound pulse through a metal in a magnetic field and its dependence on the geometry of the Fermi surface are analyzed, considering first the effect of generally existing closed electron orbits and then the effect of open electron trajectories resulting from multichannel specular reflections at the boundary. Calculation based on the equations of electron kinetics and dynamics are made for both a bulky specimen and a thin layer of metal. They predict the appearance of secondary pulses of magnitudes and with lead or lag time depending on the signal width and on the magnetic field intensity. Experimental verification will require a device with an adequate pulse time resolution. The method is suitable for analyzing and testing the propagation of smoothly modulated sound waves and other magnetoacoustic effects in metals. The authors thank K. B. Tolpigo for helpful discussion. Figures 2, references 9: 8 Russian, 1 Western.

[154-2415]

UDC 534.171.534.2

#### TRANSIENT ACOUSTIC RADIATION IN TURBULENT MEDIUM

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 1, Jan-Feb 82 (manuscript received 6 Nov 80) pp 96-101

PAVLOV, V. I., Physics Faculty, Moscow State University imeni M. V. Lomonosov

[Abstract] The characteristics of transient acoustic radiation occurring during uniform and linear motion of a well-streamlined body (particle)

in a turbulent medium were found. The spectral and angular characteristics of transient acoustic radiation were considered during movement of a strong source in the turbulent medium. References 5 Russian.

[108-6521]

UDC 534.833.524

EFFECT OF ELASTIC DISSIPATIVE PARAMETERS, LOAD CHARACTERISTICS AND DEGREE OF SURFACE RESTRICTION OF VIBRATION-INSULATING ELEMENTS ON THEIR VIBRATION-INSULATING PROPERTIES

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 1, Jan-Feb 82  
(manuscript received 8 Dec 80) pp 80-84

KLYUKIN, I. I., Leningrad Shipbuilding Institute

[Abstract] Expressions of the longitudinal wave propagation constants in spaces of rubber-like material were derived with regard to experimental data on the frequency dependence of the coefficient of dissipative losses and the modulus of elasticity of the material and the degree of restriction of the surface by the edges of the spacers. The effect of these factors on the vibration insulation of the spacers was determined. An increase of the modulus of elasticity with frequency caused a decrease of the vibration-insulating effect. The frequency dependence of the modulus and the loss coefficient are such that their effect on the vibration insulation compensates each other for a given grade of soft rubber manufactured from synthetic latex. The positive role of dissipative losses at high frequencies is manifested only at wave resonances of the spacers whose frequencies are located between the given frequencies. Figures 4, references 7:  
6 Russian, 1 Western.

[108-6521]

UDC 534.32:628.517.2:699.84

SOUND INSULATION OF PLATE FACED WITH ELASTIC LAYERS

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 1, Jan-Feb 82  
(manuscript received 19 Dec 80) pp 58-64

ZABOROV, V. I., All-Union Scientific Research Institute of Protection of Labor and Safety Engineering of Ferrous Metallurgy

[Abstract] Sound insulation of a plate faced on one or two sides by elastic isotropic layers was investigated on the assumption that the elastic layer is deformed only in the direction transverse to the plane of the plate. The effect of wave resonances in elastic layers on sound insulation of the designs is shown. A series of boundary-value equations is derived to find

the transverse displacements of the external surfaces of the layers and stresses in the contact planes of the layers and plate. Simple formulas for additional sound insulation of the plate when it is faced with elastic layers were found for different frequency bands. Figures 4, references 3: 2 Russian, 1 Western.

[108-6521]

UDC 534.286

#### ACOUSTIC PROPERTIES OF LIQUID CRYSTALS IN PULSATING MAGNETIC FIELDS

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 1, Jan-Feb 82  
(manuscript received 16 Dec 80) pp 14-18

GEVORKYAN, E. V., LAGUNOV, A. S. and ERGASHEV, D., All-Union Correspondence Institute of Machine Building

[Abstract] The properties of liquid crystals of n-n-methoxybenzylidene-n-butyylaniline, n-n-ethoxybenzylidene-n-butyylaniline and mixtures of them in a 2:1 and 1:1 ratio were investigated for the effect of a pulsating magnetic field on the acoustic properties of these crystals. The time functions of the ultrasound absorption coefficient of binary liquid-crystal mixtures of the two compounds were found at different parameters of state such as temperature, pressure, magnetic induction and concentration. The time functions are determined by the material constants of nematic liquid crystals. Figures 6, references 3: 2 Russian, 1 Western.

[108-6521]

#### FEASIBILITY OF MAKING ACOUSTIC SENSORS BASED ON MULTIMODE STEP-INDEX FIBER

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 5, 12 Mar 82 (manuscript received 21 Jul 81, after revision 23 Dec 81) pp 284-287

MAYEVSKIY, S. M., NAZAROV, V. D. and PETRIK, V. F.

[Abstract] Experiments are done to determine the feasibility of using a multimode fiber with stepwise change in refractive index profile as a sensor of acoustic waveforms. The studies were done on two sections of fiber 5 m long with core diameter of 60  $\mu\text{m}$  and shell diameter of 150  $\mu\text{m}$ . The numerical aperture of the fiber was 0.2, and the coefficient of attenuation was 12 dB/km. The experiments involved using the proposed sensor as a hydrophone in a Mach-Zehnder fiber-optics interferometer arrangement. The sensing arm of the interferometer was the fiber coiled into a helix 50 mm in diameter and immersed in water. The acoustic signal was produced by a piezoceramic transducer on a frequency of 10 kHz. The control was a calibrated piezoceramic hydrophone with sensitivity of 100  $\mu\text{V/Pa}$ . The results

showed a measurement sensitivity of the same order as the piezoceramic unit, about 80  $\mu$ V/Pa. The sensitivity can be increased by increasing the length of the fiber in the helix, subject to the limitation of attenuation with increasing length. Figures 2, references 5: 1 Russian, 4 Western.  
[141-6610]

UDC 532.12:534.22

#### CALCULATING SPEED OF SOUND IN CADMIUM-ZINC LIQUID ALLOYS

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 20, No 1, Jan-Feb 82  
(manuscript received 9 Feb 81) pp 185-187

LANDA, A. I., PANIN, V. Ye. and ZHOROVKOV, M. F., Institute of Optics of the Atmosphere, Siberian Department, USSR Academy of Sciences

[Abstract] Successful calculation of the speed of sound in liquid metals is possible only with a reliable model of structure and interionic interaction in melts that enables description of equilibrium volumes and elastic characteristics. The most widely used approach for handling the problem at present is a pseudopotential formalism for describing the energy of the melt and solving the Perkus-Jevik equation in the hard sphere (HS) approximation to describe the structure of the melt. It has been shown that the contribution of the electronic subsystem to compressibility can be accounted for by introducing the experimentally measured coefficient of volumetric expansion. The authors extend the technique to calculation of the speed of sound in binary melts. The free energy of the binary melt is calculated by the pseudopotential method in the Born approximation and the thermodynamic theory of perturbations. The structure of the ionic subsystem is described by exact solution of the Perkus-Jevik equations for partial functions of paired distribution in the hard sphere approximation. Calculations of the speed of sound in Cd-Zn melts agree well enough with experimental data to recommend the method for practical calculations. Figure 1, table 1, references 9; 6 Russian, 3 Western.

[142-6610]

## CRITICAL PHENOMENA

UDC 621.391.812

### PATTERNS OF CRITICAL SYNCHRONIZATION EFFECTS ACCOMPANYING SIGNAL PROPAGATION IN NONLINEAR MEDIA AND SYSTEMS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 262, No 2, Jan 82  
(manuscript received 4 Aug 81) pp 325-328

BAKHRAKH, L. D., associate member, USSR Academy of Sciences,  
YEVTIKHIYEV, N. N., KUZ'MIN, V. I. and GAKIN, A. I., Moscow Institute  
of Radio Engineering, Electronics and Automation

[Abstract] The authors consider effects due to frequency synchronization at the input and output of nonlinear systems and media with signal propagation through them. For systems of the relaxation type with exponential and power-law behavior of characteristics, there are geometric progressions of the values of these characteristics that determine transition to a new state, i.e. critical phenomena. For exponential processes, the modulus of such a progression is the base of the natural logarithms, e, and for processes described by power-law functions, the modulus is  $e^e$ . Since propagation of electromagnetic and acoustic signals in nonlinear media is a relaxation process with characteristics that are often describable by exponential and power-law relations, experiments are done to determine whether there are series of the geometric progression type for such processes with these moduli that determine the change in properties of the system and medium where boundaries typical of phase transitions will be located. In calculating the sequences of critical values of frequencies, one of the critical frequencies was taken as that corresponding to emission or absorption of electromagnetic energy accompanying a change in state of the hyperfine structure of the hydrogen atom:  $f_0 = 1\ 420\ 405\ 751.800 \pm 0.028$  Hz. To calculate the sequential critical frequencies, the authors used the relations  $f_n = f_0 q^n$ ,  $q = e$  or  $q = e^e$  ( $n = 0, \pm 1, \pm 2, \dots$ ). An oscillator generated a signal on a critical frequency that was sent to a nonlinear signal converter. The signal taken from the converter output on a frequency greater or less than that of the oscillator frequency by a factor of  $e$  or  $e^e$  was sent to a receiver in which the frequency was fixed, after which the oscillator and receiver signals were continuously tuned while holding the receiver signal at maximum. It was found that there is a continuous relation between oscillator and receiver frequency that passes through the calculated critical point with coordinates represented by frequencies of the oscillator and receiver differing by a factor of  $e^2$  and  $e^e$ . Figures 2, table 1, references 9 Russian.

[103-6610]

CRYSTALS AND SEMICONDUCTORS

ABSORPTION OF ENERGY OF LOW-FREQUENCY ELECTROMAGNETIC AND ACOUSTIC FIELDS  
BY NON-KRAMERS  $Ho^{3+}$  IONS IN  $CaWO_4$  SINGLE CRYSTAL

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 82, No 3, Mar 82 (manuscript received 3 Oct 81) pp 888-898

GRINBERG, Ye. S., DUGLAV, A. V. and KOCHELAYEV, B. I., Kazan' State  
University imeni V. I. Ul'yanov-Lenin

[Abstract] Absorption of electromagnetic and acoustic field energy by a non-Kramers  $Ho^{3+}$  ion in a paramagnetic  $LiTmF_4$  or preferably  $CaWO_4$  single crystal (the latter having a higher holmium content, 0.5 atom.% Ho, and a less anisotropic magnetostriction effect) is examined on the basis of calculations involving spin and interaction hamiltonians, also on the basis of experimental data on absorption of the energy of longitudinal ultrasound and of a low-frequency alternating magnetic field parallel to the external constant magnetic field in resonance studies. Local singularities in the field dependence of absorption are revealed at intensities of the external magnetic field corresponding to intersection of hyperfine sublevels in the holmium ion. A theory is developed that explains this by Orbach-Aminov relaxation at 4.2 K (above 2.0 K) and direct transitions between energy levels at their intersections at 1.6 K (below 2.0 K). The authors thank A. G. Gurevich for suggesting a similarity between these anomalies and those, still unexplainable ones, in the spectrum of paramagnetic absorption by  $Ho^{3+}$  ions in intermetallic compounds with magnetic ordering. Figures 3, references 13: 10 Russian, 3 Western.

[154-2415]

UDC 539.216.2:535

INFLUENCE OF LASER EXPOSURE ON SILICON DIOXIDE FILM STRUCTURE WITH  
IMPLANTED PHOSPHORUS IONS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 36, No 3, Mar 82  
(manuscript received 11 Mar 81) pp 413-416

SELEZNEV, B. I., YEMEL'YANOVA, G. M., TKAL', V. A. and MAKUSHKIN, B. V.

[Abstract] Infrared transmission spectroscopy is used to study the effect of laser irradiation on the structure of silicon dioxide films implanted

with phosphorus ions. The silicon dioxide films were formed on silicon and germanium backings by thermal oxidation of silicon in dry and moist oxygen, reactive cathodic sputtering of silicon, oxidizing silane with oxygen, and pyrolysis of tetraethoxysilane. The films were irradiated with  $P^+$  ions with energy of 100 keV in doses of  $10^{14}$ - $10^{16}$   $cm^{-2}$ . Laser irradiation was done at room temperature on a neodymium glass laser ( $\lambda = 1.06 \mu m$ ) in the free lasing mode (pulse duration  $8 \cdot 10^{-4}$  s). It was found that laser exposure eliminates radiation structural defects and partly restores the film structure to the initial state (before implementation). The annealing effect is observed for all films with exposure to neodymium laser millisecond pulses with energy of 3.5, 5 and 10  $J/cm^2$ . The effects of annealing radiation defects in the films under the action of laser irradiation can be attributed to local heating as a result of absorption of laser emission by radiation defects, and the annealing efficiency depends on the method of film formation and on moisture resistance. Figures 3, references 12: 6 Russian, 6 Western.  
[143-6610]

ELECTRICITY AND MAGNETISM

UDC 621.396.677.012

MODIFICATION OF METHOD OF PARTIAL DIAGRAMS TO SYNTHESIZE SECTOR RADIATION PATTERNS OF ANTENNA ARRAYS

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 1, Jan-Feb 82  
(manuscript received 30 Jun 80) pp 42-45

DOBROVOL'SKIY, Yu. Yu. and RUBANOV, I. L.

[Abstract] A modification of the method of partial diagrams that includes introduction of only phase distribution by the elements of an acoustic antenna array was considered. The partial diagrams were found by minimization of the error functional. The suggested modification makes it possible to synthesize the radiation pattern with few deviations from the ideal sector pattern. The characteristic feature of the proposed modification of the method of partial diagrams is that introduction of phase distribution that provides formation of the required sector diagram simultaneously leads to some deformation of the radiation pattern. Sector radiation patterns of antenna arrays of comparatively small wave dimensions with constant amplitude distribution can be satisfactorily synthesized by using the suggested method, which permits optimum use of the radiating antenna array under conditions of strength limitations. Figures 4, references 4 Russian.  
[108-6521]

EFFECTS ACCOMPANYING GENERATION OF ULTRASTRONG PULSED MAGNETIC FIELDS

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 4, 26 Feb 82 (manuscript received 26 Nov 81) pp 240-245

ANDRIANOV, A. M., ANAN'YEV, S. P., GENNADIIYEV, N. N., DEMICHEV, V. F. and LEVIT, P. A., Institute of Atomic Energy imeni I. V. Kurchatov, Moscow

[Abstract] The paper gives the results of experiments done to explain the behavior of ultrastrong magnetic field generation with thin-walled solenoids. Single-turn solenoids made of sheet copper 0.5 mm thick were studied. The inside diameter of the solenoids was 3 mm, and the length was 3, 5 and 7 mm in three series of experiments. The current source was a capacitor bank with

capacitance of 120  $\mu$ F, maximum voltage of 30 kV and self-inductance of 6 nH. Measurements were made of the time behavior of current through the solenoid, voltage drop across the solenoid, and the time derivatives of current and magnetic field strength. Results showed that the amplitude values of the magnetic field ( $1.5 \cdot 10^8$ - $1.6 \cdot 10^8$  A/m) exceed the calculated values even when current density is assumed to be uniformly distributed lengthwise of the solenoid. The dependence of field on current is faster than linear. The radial dimensions of the solenoid do not change up to the maximum of the field. Magnetic field generation is accompanied by an abrupt rise in voltage across the solenoid (9-11 kV) due to an increase in the resistive component of impedance. The analogous voltage across a thick-walled solenoid 5 mm long does not exceed 2.4 kV, and is determined mainly by inductance. The maximum rate of energy input to the solenoid is  $(2-3.5) \cdot 10^{10}$  W/g, or about 20 eV/ $\mu$ s·atom, and maximum magnetic pressure is 160,000 atmospheres. Destruction of the solenoid material is explosive with an abrupt drop in voltage across the solenoid and a bright flash with much higher intensity of optical emission than for thick-walled solenoids. Figures 2, table 1, references 9: 4 Russian, 5 Western.

[140-6610]

## FLUID STATICS

UDC 532.612.4

TECHNIQUE AND EXPERIMENTAL FACILITY FOR STUDYING DENSITY AND SURFACE TENSION OF MOLTEN METALS AT HIGH TEMPERATURES

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 20, No 1, Jan-Feb 82  
(manuscript received 29 Mar 81) pp 54-58

SHPIL'RAYN, E. E., FOMIN, V. A. and KACHALOV, V. V., Institute of High Temperatures, USSR Academy of Sciences

[Abstract] A method is proposed for precision determination of surface tension in a two-capillary version of the maximum bubble pressure technique. In contrast to the classical method proposed by Sagden, the manufacture of the working section is simplified by placing the ends of the capillaries at different levels. An advantage of this method is that both density and surface tension can be determined from measurements in a single experiment over a wide range of variations in the state parameters. A facility for implementing the method is described that contains a crucible, a capillary system, pulse tubes and a capillary transport mechanism. The unit is based on the SShVL-0.62/25 laboratory vacuum furnace with VA-0.5-4 vacuum system. Temperature measurement is by three PR-20/6 thermocouples uniformly spaced heightwise, and an R-308 potentiometer. The inert gas pressure required for making bubbles is measured with a U-shaped manometer filled with silicone oil. A U-19 thermostat keeps the temperature of the manometric fluid constant within 0.05°C. An IZV-21 optimeter measures the relative depth of immersion of the capillaries with accuracy of 0.001 mm. As an example of the accuracy of the measurements made on this facility, studies on barium in the liquid phase gave the density accurate to 0.5%, and surface tension accurate to 2% for maximum temperature of 1580°C. Figures 2, references 8: 3 Russian, 5 Western.

[142-6610]

LASERS AND MASERS

UDC 541.124/128

HOW CONFIGURATION OF SUPERSONIC NOZZLE SECTION AFFECTS RATE OF MOLECULE REARRANGEMENT BY VIBRATIONAL LEVELS IN GASDYNAMIC CARBON MONOXIDE LASER ACTIVE MEDIUM

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian No 1 (131), Jan-Feb 82 (manuscript received 16 Dec 80) pp 69-75

VASILIK, N. Ya., MARGOLIN, A. D. and SHMELEV, V. M., Moscow

[Abstract] Steady adiabatic quasi-one-dimensional flow of a CO+ Ar mixture through a flat supersonic nozzle is analyzed, assuming equilibrium with respect to all translational and rotational degrees of freedom in the critical nozzle section. The equations of vibrational relaxation kinetics are solved by numerical integration, giving estimates of gain for vibrational-rotational transitions and the populations of vibrational levels in CO molecules in various sections of the supersonic nozzle segment. As such a gas flows through an expanding nozzle, the maximum of the amplification factor is found to shift monotonically toward lower vibrational levels. At a fixed vibrational level or with an increasing gas expansion ratio, on the other hand, the path along which the population of a given level builds up to a quasi-steady magnitude in a channel of uniform cross section is found to become longer. The results of calculations as well as experimental data on 20% CO+ 80% Ar and 5% CO+ 15% N<sub>2</sub>+ 80% Ar mixtures with gas expansion to temperatures of 30-200 K and with temperatures in the critical nozzle section ranging from 1000 to 3000 K indicate how the redistribution of CO molecules by vibrational levels depends on the nozzle profile, particularly on the distance from the critical section. In pure carbon monoxide or in mixtures with a low concentration of the inert component, gain will increase as the temperature of the active medium drops due to expansion, but a slowdown of V-V exchange processes due to lower density and temperature can decrease gain. Figures 5, references 15: 9 Russian, 6 Western.

[159-2415]

REGENERATIVE FIBER-OPTICS LASER AMPLIFIER

Tbilisi SOOBSHCHENIYA AKADEMII NAUK GRUZINSKOY SSR in Russian Vol 104, No 2, Nov 81 (manuscript received 3 Jul 81) pp 329-332

DZHIBLADZE, M. I., ERIKASHVILI, R. R., TEPLITSKIY, E. Sh., MELIKISHVILI, Z. G. and CHIANURASHVILI, N. R., Tbilisi State University

[Abstract] The performance of a fiber-optics neodymium-glass laser amplifier was studied, with a similar device emitting periodic pulses used as the master oscillator. Glass fibers 1 m long and 40  $\mu\text{m}$  in diameter were activated with neodymium over a 40 cm long segment each and then excited from a gas-discharge flash tube. The active amplifier fibers were coupled to the active oscillator fibers through a glass capillary and the magnitude of the signal at the amplifier input was varied through variation of the length of that coupling. The amplifier gain was measured as a function of the pump energy, and as a function of the input signal intensity at various levels of pump energy from 400 to 530 J. The gain for the first and next few oscillator pulses was found to depend exponentially on the pump energy without saturation, indicating a regenerative mode of amplification at high pumping levels. In the range of low input signal intensities the gain was found to decrease after peaking, due to spontaneous emission in the amplifier. According to the results of these experiments, a gain of  $10^5$  is feasible at the optimum signal and pumping levels with the optimum time delay of 150-180  $\mu\text{s}$  from start of pumping to input of signal. The article was presented by T. I. Sanadze, associate member, GSSR Academy of Sciences, on 25 June 1981. Figures 3; references 5: 4 Russian, 1 Western.

[155-2415]

OPTICAL WAVEGUIDE CAVITIES FOR LASERS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 36, No 2, Feb 82 (manuscript received 22 Apr 81) pp 205-207

VASHKEVICH, I. M. and UVAROVA, N. N.

[Abstract] Multipass optical cavities of waveguide type are developed on the basis of neodymium glass pentagonal prisms. The path length of the optical radiation is increased by increasing the number of passes per cycle. The two longest faces of the prism are plane-parallel, and the angles of the other three faces are selected so that for given geometric dimensions there are no closed cycles except for rays that are normally incident on the output face. In such a design, there is a narrow range of directions with a closed path with minimum losses, and as a result the divergence of the output emission is quite small. Experiments with cavities of the proposed type in

a one-lamp cylindrical air-cooled quartz reflector yielded lasing with threshold of about 500 J, duration of 200-250  $\mu$ s, and energy of up to 5 J with triple-threshold pumping. Lasing divergence was no more than  $1.5 \cdot 10^{-3}$  and  $4.3 \cdot 10^{-3}$  across and along the spot respectively. The proposed technique optimizes lasing conditions without the application of additional dielectric reflective coatings. Figures 2, references 6 Russian.  
[136-6610]

UDC 621.375.826

#### COPPER VAPOR LASER EFFICIENCY

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 20, No 1, Jan-Feb 81  
(manuscript received 10 Mar 81) pp 177-180

BATENIN, V. M., VOKHMIN, P. A., KLIMOVSKIY, I. I. and SELEZNEVA, L. A.,  
Institute of High Temperatures, USSR Academy of Sciences

[Abstract] The efficiency of copper vapor lasers has been analyzed both theoretically and experimentally. Theoretical research has concentrated on the coefficient  $\eta_d$  of conversion of electric energy invested in the discharge to lasing energy up to the instant of termination of the laser pulse, while the experimental parameter has been the practical efficiency  $\eta_{pr}$ , i.e. the coefficient of conversion of stored energy to lasing energy. The authors attempt a comparison of theoretical and experimental results with consideration of losses associated with the discharge circuit that reduce the value of  $\eta_{pr}$  as compared with  $\eta_d$ . It is shown that in copper vapor lasers at  $T_e \sim 5$  eV and a ratio of  $n_{Cu}/n_{Ne} \sim 0.1$  the coefficient of conversion of energy invested in the discharge to energy of induced emission may reach  $\sim 7\%$ . When the specific energy output is approximately 1/10 of the maximum possible, values of  $\eta_d$  on a level of 20% are possible in copper vapor lasers. This increase in efficiency with decreasing percentage of atoms participating in lasings is due to the reduction in losses of energy by electrons associated with excitation and ionization of resonantly excited copper atoms. Figures 3, references 11: 10 Russian, 1 Western.

[142-6610]

UDC 621.373.8

#### LIGHT-INDUCED OPTICAL NONRECIPROCITY IN RING GAS LASER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 36, No 3, Mar 82  
(manuscript received 4 May 81) pp 383-388

KUZNETSOV, V. M., RUBANOV, V. S. and SVIRINA, L. P.

[Abstract] An investigation is made of nonreciprocity of counterwaves in a ring gas laser in which the active element is irradiated by emission of

a linear gas laser that operates on the same transition as the ring laser. The theoretical analysis is done in W. R. Bennett's formalism, disregarding the influence of coherent effects like population modulation as well as wave backscattering. It is shown that exposure to an external traveling wave field gives rise to a difference in the initial gains for opposed directions in the ring laser, resulting in a difference of intensities of opposed waves. Irradiation by a linear laser also causes a difference in the lasing frequencies of opposed waves that may reach tens of kilohertz. An experiment is described in which a ring laser is exposed to radiation from a helium-neon linear laser. The emission wavelength of the lasers was  $1.15 \mu\text{m}$ . The beat frequency of opposed waves in the ring laser was plotted as a function of tuning of the linear laser for different detuning of the ring laser relative to the line center. The maximum frequency difference is observed when the ring laser is tuned near the center of the lasing transition, reaching 40 kHz. Figures 4, references 4: 3 Russian, 1 Western.

[143-6610]

UDC 621.375.82

#### THRESHOLD AND SPECTRAL CHARACTERISTICS OF RAMAN LASER AS FUNCTION OF SPATIALLY PERIODIC PUMPING PERIOD

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 36, No 3, Mar 82  
(manuscript received 9 Mar 81) pp 396-402

APANASEVICH, P. A., AFANAS'YEV, A. A., GRABCHIKOV, A. S., KOROL'KOV, M. V. and ORLOVICH, V. A.

[Abstract] Theoretical and experimental studies are done on the way that the threshold and spectral characteristics of a Raman laser with distributed feedback depend on modulation period  $\Lambda$  (interference pattern of pumping) that determines the Bragg frequency near which coupling is most effective between Stokes waves. Calculations show that the influence of distributed feedback on parameters of the Raman laser depends considerably on the phases determined by the geometry of an experiment (optical thicknesses and relative location of all components of the optical cavity, phase of the interference pattern of the pumping radiation), and the mirrors. Experiments were done with excitation by a ruby laser with passive Q-switching. The pumping radiation was incident on a cell with nitrobenzene. The cell is mounted so that it can be turned through a wide range of angles between the normal to its surface and the direction of pumping radiation. The forward surface of the cell has a reflection-reducing coating, and the rear surface has reflectivity near 100% for the wavelengths of the pumping radiation and the first Stokes component of stimulated Raman scattering. The output mirror has reflectivity of 80%. Experimental results showed a reduction of threshold intensity of pumping of more than 30% due to distributed feedback. The emission spectrum of the Raman laser can be tuned over the width of the Raman scattering line with variation of the period of the pumping interference field. Figures 4, references 10; 9 Russian, 1 Western.

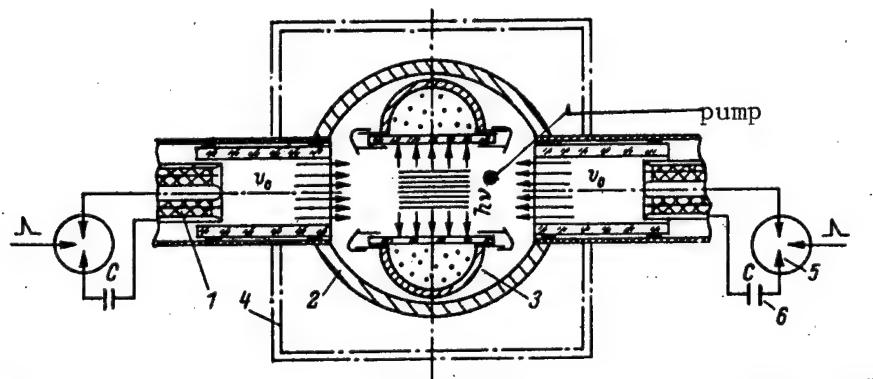
[143-6610]

MOLECULAR IODINE LASER WITH WIDE-BAND OPTICAL PUMPING BY POLYCHANNEL CUMULATIVE DISCHARGE OF MAGNETOPLASMA COMPRESSOR

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 4,  
26 Feb 82 (manuscript received 13 Jul 81) pp 220-224

KAMRUKOV, A. S., KASHNIKOV, G. N., KOZLOV, N. P., KUZNETSOV, S. G.,  
ORLOV, V. K. and PROTASOV, Yu. S., Moscow Higher Technical Academy  
imeni N. E. Bauman

[Abstract] Lasing is achieved in iodine vapor in experiments with wide-band optical pumping by the emission of a polychannel cumulative discharge of a magnetoplasma compressor. The experimental setup is shown in the diagram. The active medium was excited by radiation from a shock-heated plasma formed by collision and accumulation of high-velocity head-on plasma streams produced by six magnetoplasma compressors 1 arranged in groups of three on each side of discharge chamber 2. The inside diameter of the chamber was 120 mm, and length was 300 mm. Two identical cells 3 containing the active substance were placed inside the chamber parallel to its axis. The cells were made of stainless steel with three flat windows of MgF<sub>2</sub> through which the pumping radiation was coupled into the active medium. On the end flanges of the cells were either quartz windows for studying luminescence characteristics, or adjustable quartz mirrors to form an optical cavity (laser cells). Brightness of the shock-compressed plasma in the iodine absorption band was enhanced by a xenon atmosphere of 1-3 torr in the discharge chamber. The use of a cumulative discharge in low-pressure gas instead of a vacuum discharge enabled effective tuning of the plasma emission spectrum. The buffer gas in the working cells was perfluoromethane. Lasing was observed on 342.0 and 342.4 nm corresponding to transitions with vibrational numbers of 1-14 and 2-15. Lasing pulse duration at half-amplitude was 1-1.5  $\mu$ s. Figures 2, references 5: 3 Russian, 2 Western.



1--magnetoplasma compressor; 2--discharge chamber;  
3--cell with active substance; 4--thermostat;  
5--discharger; 6--capacitive accumulator

[140-6610]

POWERFUL ELECTRON-BEAM CONTROLLED XeCl\* EXCIMER LASER IN UV SPECTRAL REGION

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 4, 26 Feb 82 (manuscript received 18 Jun 81, after revision 19 Jan 82) pp 245-250

BASOV, N. G., VAKHANEV, M. B., DANILYCHEV, V. A., DEGTYAREV, A. G., ZARUDIN, V. G., KAZAKOVTSOV, V. A. and KERIMOV, O. M.

[Abstract] The paper describes a pulsed laser with working volume of 40 liters (200 x 20 x 10 cm) based on the XeCl\* molecule excited by electro-ionization. Energy, threshold and spectral characteristics of the laser are investigated. The electron beam generator consists of a six-stage Marx pulse voltage generator with impact capacitance of 0.27  $\mu$ F, charging voltage of 75 kV, and six vacuum diodes separated from the laser chamber by aluminum foil or mylar film. The separative foil was backed by a grating with transparency of about 70%. The optical cavity was formed by an opaque spherical aluminum mirror with radius of curvature of 10 m, and a flat dielectric mirror with reflectivity of 50%. At the input to the discharge gap the electron beam had the following parameters: electron energy 200 keV, electron current 16 kA, electron current density 4 A/cm<sup>2</sup>, and pulse duration at half-amplitude 0.8  $\mu$ s. For the optimum mixture of Ar:Xe:CCl<sub>4</sub> = 1:60:1800, at pressure of 1-1.5 atm, lasing on a wavelength of 308 nm was observed with pumping by electron beam alone. Threshold pumping power for the optimum mixture pressure of 1.5 atm was 15 kW/cm<sup>3</sup>, and maximum output energy was 4.8 J. Measurements of laser emission energy as a function of the charging voltage of the capacitor bank for the optimum mixture show a maximum of 20.5 J (about 35 MW) at charging voltage of 25 kV with efficiency of the energy invested in the gas of about 1%. Figures 3, references 2: 1 Russian, 1 Western.

[140-6610]

UDC 621.373:535

AMPLITUDE CHARACTERISTICS OF UNSTEADY TWO-ISOTOPE RING GAS LASER EMISSION

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 52, No 3, Mar 82 (manuscript received 9 Nov 81) pp 398-399

SHPAK, I. V., KUZNETSOV, I. M. and KUZ'MENKO, V. I.

[Abstract] An examination is made of the behavior of counter wave intensities in a ring laser with unsteady optical cavity as a function of rate of entry into the four-wave zone as major laser parameters are varied. A helium-neon two-isotope laser was studied (He<sup>3</sup>:Ne<sup>20</sup>:Ne<sup>22</sup> = 15:1:1) with wavelength of 0.6328  $\mu$ m. The cavity was formed by four mirrors with inter-mode spacing c/L = 360 MHz. A Faraday nonreciprocal device was used to get a frequency difference of 120 kHz between counter waves. Unsteadiness was introduced by applying a control voltage to a piezoceramic transducer connected

to one of the mirrors. Experiments showed that for a certain ratio between the amplitude of frequency deviation of the laser, excess of inverse population over the threshold and initial mode position, there is a non-zero difference of intensities of counter waves in contrast to the case of a quasi-steady change in the cavity perimeter. The counter wave intensity difference shows threshold dependence on the amplitude of frequency deviation. A necessary condition for attainment of the threshold is that the band of laser frequency deviation must be twice the width of the two-mode lasing zone. While the intensity difference is symmetric relative to the luminescence line, there is a reduction in the amplitude of the difference by approximately 20% at mismatches corresponding to a reduction in mode frequencies as compared with an increase. The intensity difference shows extremum behavior as a function of deviation frequency. An increase in amplitude of the deviation shifts the maximum toward higher frequencies. The effect is interpreted as dynamic desynchronization of four-wave synchronized lasing in the region of transition from four-wave to two-wave lasing. Figures 2, references 4 Russian. [144-6610]

UDC 534.1

#### STOCHASTIC MASER EMISSION STATES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 263, No 2, Mar 82  
(manuscript received 6 Oct 81) pp 328-331

VLADIMIRSKIY, K. V. and NORVAYSHAS, A. A., Physics Institute  
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[Abstract] The authors consider aperiodic stochastic solutions of equations of dynamics of a nuclear Zeeman maser working on a nonuniformly broadened line. The geometry and statistical properties of such solutions are studied, as well as their relation to limiting cycles. The mathematical model assumed for interaction of matter with the resonator field corresponds to conditions in which stimulated emission on the resonant frequency of the material is realized with maximum accuracy: it is assumed that the relaxation width of the line is considerably less than the width of the frequency response of the resonator. In accordance with this, the processes in the material are described exactly in the formalism of Bloch's equations, and the relationship between nuclear magnetization and the rf field is characterized by the steady-state solution of the resonator equation. The field in the resonator is taken as circularly polarized. The equations derived with these assumptions are axially symmetric and are not changed by rotation of the coordinate axes around the direction of the constant polarizing field. The simplest model of nonuniform broadening is considered: a symmetric double line. Numerical solution of the derived equations shows diversity of filling of phase space and complicated time behavior. The solutions can be divided into two classes depending on stability or instability. The less stable solutions encompass

all six variables and can be subdivided into symmetric and asymmetric. The more stable solutions are three-dimensional. These may be "metastable" where long periods of three-dimensional emission alternate with spontaneous transitions to the six-dimensional mode, reverting to three-dimensional stochastic oscillations with a change in phase. Figures 2, references 5:  
2 Russian, 3 Western.  
[148-6610]

NUCLEAR PHYSICS

UDC 533.916.07

USING  $m = 0$  INSTABILITY OF Z-PINCH LINER FOR THREE-DIMENSIONAL PLASMA IMPLOSION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 263, No 2, Mar 82  
(manuscript received 18 Nov 81) pp 322-324

ALIKHANOV, S. G. and BAKHTIN, V. P., Institute of Atomic Energy  
imeni I. V. Kurchatov, Moscow

[Abstract] Previous research has shown that volumetric compression by the magnetic pressure of an imploding Z-pinch liner for nuclear fusion purposes reaches no more than 400 when a cylindrical configuration is used. The authors consider the feasibility of achieving three-dimensional plasma implosion without sacrificing the advantages of shell acceleration by longitudinal current. The evolution of a sausage instability ( $m = 0$ ) is considered for the case where a liner accelerated by an azimuthal magnetic field compresses a longitudinal magnetic field. It is assumed that the liner is homogeneous in the azimuthal direction and has periodic inhomogeneity in the axial direction. Since the intensity of the magnetic pusher field is inversely proportional to the radius of the liner, pinches are formed in the thinnest sections. Each such pinch generates waves moving in opposite directions toward the parts of the liner that implode most slowly, resulting in nearly closed volumes that are both radially and axially compressed. Under the proper conditions, the compressed cavity develops without axial cumulative jets. Figure 1, references 5: 4 Russian, 1 Western.

[148-6610]

## OPTICS AND SPECTROSCOPY

### MANIFESTATIONS OF ROTATIONAL AND VIBRATIONAL RELAXATION IN ISOTROPIC RAMAN SCATTERING SPECTRA OF CARBON MONOXIDE AND NITROGEN

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI  
in Russian Vol 35, No 2, 20 Jan 82 (manuscript received 2 Dec 81) pp 65-68

GOLUBEV, N. S., ORLOVA, N. D. and PLATONOVA, L. A., Scientific Research Institute of Physics, Leningrad State University imeni A. A. Zhdanov

[Abstract] The contours of isotropic bands of pure carbon monoxide and nitrogen and mixtures of them with  $CF_4$  and  $CO_2$  with overall density variation of 7-380 amagat units were investigated for rotational and vibrational relaxation. The contour of the carbon monoxide band mixed with carbon monoxide is initially strongly asymmetrical and then becomes symmetrical. Broadening of the band caused by vibrational dephasing occurs in this system simultaneously with collapse of the rotational structure. The nitrogen band under the same conditions reveals only the effect of vibrational relaxation despite the similarity of the properties of nitrogen and carbon monoxide molecules. Figures 2, references 14: 7 Russian, 7 Western.

[107-6521]

### FIRST- AND SECOND-ORDER RAMAN SCATTERING IN ACOUSTIC SOFT MODE WITH BRILLOUIN ZONE BOUNDARY IN $Hg_2(Cl_xBr_{1-x})_2$ CRYSTALS

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI  
in Russian Vol 35, No 2, 20 Jan 82 (manuscript received 27 Nov 81) pp 62-65

BARTA, Ch., DOBRZHANSKIY, G. F., LIMONOV, M. F., MARKOV, Yu. F. and SIGOV, A. S., Physical-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences

[Abstract] Low-frequency Raman scattering spectra of mixed  $Hg_2(Cl, Br)_2$  crystals in paraphase and ferrophase were investigated in the acoustic soft mode from the Brillouin zone boundary. The soft mode prohibited in first-order optical spectra by selection rules was induced by long-range static distortions created by substitution defects and inhomogeneities of the composition of mixed  $Hg_2(Cl, Br)_2$  crystals. The dependence of scattering intensity on interatomic force constants is complicated by violation of

translation symmetry in the lattice. Numerical calculations show that the experimental results and conclusions of simple theory are in satisfactory agreement but the agreement is qualitative due to the large number of simplifying assumptions. Figures 3, references 8: 7 Russian, 1 Western. [107-6521]

UDC 535.36

STIMULATED RAMAN SCATTERING IN FIELD WITH PHASE MODULATED BY MARKOV PROCESS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 36, No 2, Feb 82  
(manuscript received 30 Mar 81) pp 220-225

ZENENKO, A. A.

[Abstract] In previous research on stimulated Raman scattering, the problem of amplification of the Stokes signal in a non-gaussian pumping field has been analyzed for a model in which the pumping field is a continuous phase-modulating Markov process. Such a model can successfully describe stabilized lasers that operate above the threshold of stimulated emission. The author of this paper considers stimulated Raman scattering with pumping by a laser field that is phase-modulated by a discrete Markov process. This generalization of pumping statistics enables treatment of the initiating laser field both as purely discontinuous Markov noise and as correlated noise. The analysis is based on the given-field approximation using a system of partial differential equations for the amplitudes of the Stokes field and of molecular oscillations. An exact system of equations is derived for the mean Stokes intensity, and an investigation is made of its behavior in the steady state. It is shown that phase modulation reduces the efficiency of noise conversion. Figures 2, references 13: 12 Russian, 1 Western.  
[136-6610]

UDC 536.3.031

RADIATION CHARACTERISTICS OF SUBSTANCES WITH OPTICALLY SMOOTH SURFACE

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 20, No 1, Jan-Feb 82  
(manuscript received 29 Mar 81) pp 109-113

ADRIANOV, V. N., Institute of Steel and Alloys, Moscow

[Abstract] Algorithms are proposed for exact and approximate determination of the indices of refraction of a substance with optically smooth surface from experimental measurements of the spectral normal degree of blackness of the surface as a function of wavelength. Results are given for various optical characteristics of metals, showing that the exact method of determining

radiation characteristics is quite reliable and effective for practical use. The approximate method based on the assumption that the indices of refraction and absorption are equal gives results agreeing with the exact method within 1-1.5% for tungsten in the wavelength range of 1-5  $\mu\text{m}$ . Figures 4, references 4 Russian.

[142-6610]

UDC 535.345.6+535.13

#### NONLINEAR TUNABLE FOUR-WAVE FILTER

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 52, No 3, Mar 82  
(manuscript received 20 Oct 81) pp 387-389

GYULAMIRYAN, A. L., MAMAYEV, A. V., PILIPETSKIY, N. F. and SHKUNOV, V. V.

[Abstract] The process of four-wave mixing in nonlinear media is effective only when conditions of synchronism are met. Deviation from optimum synchronism with a change in frequency of one of the waves or the angle between interacting waves reduces the reflectivity of the signal wave. In this paper an experimental study is done on the angle-frequency characteristic of a nonlinear four-wave reflective filter based on near-degenerate mixing of two powerful opposed reference waves with a signal wave in a medium with fast cubic nonlinearity of nonresonant type. Emission from a Q-switched neodymium laser was divided by a beam splitter. The reflected part of the beam was passed through a cell with carbon disulfide to form the first reference wave, and reflected back by a prism to form the second reference wave at an angle of  $5 \cdot 10^{-4}$  rad to the first reference wave. The wave transmitted by the beam splitter excited stimulated Mandelstam-Brillouin scattering in a cell with acetone. The reversed Stokes wave with frequency shift of 3.2 GHz relative to the laser frequency was used to produce the signal wave directed to the carbon disulfide cell. The angle between the signal wave and one of the reference waves was  $4 \cdot 10^{-2}$  rad. A quartz plate rotated the polarization of the reference waves through  $90^\circ$  relative to that of the signal wave. Interaction in the carbon disulfide produced a wave directed opposite to the signal wave. Photodiodes were used to measure the energy of the incident and reversed signal waves, and the results were used to determine signal wave reflectivity. The results show that four-wave mixing is highly selective with respect to the frequency of the signal wave and the deviation from collinearity of the reference waves. The total width of the frequency band of effective signal reflection was about 6 GHz. Figures 2, references 9: 5 Russian, 4 Western.

[144-6610]

UDC 535.417+539.238

USING FOURIER SPECTROMETRY TO STUDY THIN FILMS BY ELECTROMAGNETIC SURFACE WAVES

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 52, No 3, Mar 82  
(manuscript received 29 Oct 81) pp 395-398

ZHIZHIN, G. N., MOSKALEVA, M. A., SIGAREV, A. A. and YAKOVLEV, V. A.

[Abstract] Experiments are done on using commercial Fourier spectrometers to extend the wave band accessible to electromagnetic surface wave spectroscopy. Measurements in the range of wave numbers of  $650\text{--}2500\text{ cm}^{-1}$  were done on the Digilab FTS-20B Fourier spectrometer. A thermal source of emission was used, and an HgCdTe detector cooled to liquid nitrogen temperature. A diffraction grating converted the volumetric emission to electromagnetic surface waves. The electromagnetic surface wave device was a glass plate with two gratings. A copper layer was applied to the surface of the plate by vacuum sputtering, and the gratings were produced holographically, using ionic etching. Each grating measured  $7 \times 7\text{ mm}$ , the distance between centers was  $16\text{ mm}$ , period  $6.1\text{ }\mu\text{m}$ , lines were trapezoidal in profile with depth of  $0.5\text{ }\mu\text{m}$ . A system of mirrors was used to direct emission to the input grating and couple out emission from the output grating. The condition for conversion of volumetric infrared radiation to an electromagnetic surface wave is  $d(1 - \cos\theta) = n\lambda$ , where  $d$  is lattice period,  $\theta$  is the angle formed in the plane normal to the grating by the wave vectors of the electromagnetic surface wave and volumetric radiation with wavelength  $\lambda$  incident on the input grating,  $n$  is a whole number. Two mirror configurations were used enabling variation of the angle of an axial ray in the incident beam over ranges of  $10\text{--}85^\circ$  and  $100\text{--}170^\circ$ . The results of the study show that electromagnetic surface waves can be produced over a wide frequency band and detected without laser sources. Figures 2, references 11: 7 Russian, 4 Western.

[144-6610]

UDC 535.39:535.36

OPTICAL PROPERTIES OF GROUND SURFACES ON NONABSORBENT MATERIALS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 52, No 3, Mar 82  
(manuscript received 16 Jul 80) pp 521-525

SKOROBOGATOV, B. S. and USOSKIN, A. I.

[Abstract] An investigation is made of optical properties of surfaces produced by grinding. Such surfaces have both external (surface) and internal (volumetric) light-scattering components. Factors are considered that influence internal scattering, and in particular the structural peculiarities of the ground surfaces. The study applies to "coarsely" ground surfaces of

nonabsorbing materials. Most structural elements of such surfaces have characteristic dimensions considerably exceeding the wavelength of light, and therefore the concepts of geometric optics apply. Relations are derived that account for the contribution made to optical characteristics by light scattering in the near-surface layers. It is shown that a primary parameter determining optical properties is the average number of fissures that cross the path of a ray of light as it propagates through the ground surface. By using formulas derived in this paper, the degree of development of the fissured layer can be determined on the basis of nondestructive optical measurements, and the optical parameters of ground surfaces can be estimated on the basis of their structure. On the basis of experimental studies of the optical properties of ground yttrium-aluminum garnet crystals the authors determine the average number of fissures intersecting a ray of light propagating in the surface layer. It is pointed out that even slight absorption can have a considerable effect on multiple scattering problems. Figures 4, references 9 Russian.

[144-6610]

UDC 621.373.826

#### BRAGG THREE-WAVE MIXING FOR OPTICAL WAVEFRONT REVERSAL

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 263, No 2, Mar 82  
(manuscript received 6 Nov 81) pp 325-327

BARANOVA, N. B. and ZEL'DOVICH, B. Ya., Institute of Problems of Mechanics, USSR Academy of Sciences, Moscow

[Abstract] A recently developed method of wavefront reversal is a three-wave mixing technique that in essence gives a conjugate wave moving in the same direction as the pumping and signal waves. The reversed wave proper in this technique is produced by a mirror that reflects the conjugate wave back. The authors propose a modification of this method in which it is assumed that square-law nonlinearity is modulated in space with a period exactly equal to the pumping wavelength in the medium. Pumping directed along the longitudinal axis of the medium results in modulation of the permittivity that is homogeneous in space and varies with the pumping frequency in time, producing wavefront reversal of any signal on half the pumping frequency. When the polarizations of the signal and reversed waves coincide, synchronism of interaction is automatic due to Bragg spatial modulation of the nonlinear constant  $\chi^{(2)}$  for all angular components of the signal, which eliminates distortions in wavefront reversal. This technique is called Bragg three-wave mixing. Numerical estimates show that the method should be effective. Figures 2, references 7; 3 Russian, 4 Western.

[148-6610]

OPTOELECTRONICS

UDC 535.417+535.317.1

INTERFEROMETRIC METHOD OF IMAGING OBJECTS WITH ARBITRARY EMISSION COHERENCE

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 52, No 3, Mar 82  
(manuscript received 15 Sep 80) pp 526-532

KURASHOV, V. N. and KHOROSHKOV, Yu. V.

[Abstract] An interferometric imaging method is considered that is based on recording the linear transform of the autocorrelation function of the radiation field of the object as realized by an optical interferometer. Such an interferometer arrangement has already been used in a technique of holography with a local reference beam to eliminate the limitations imposed by temporal coherence between the reference and object beams. It is theoretically and experimentally demonstrated in this paper that the method has broader possibilities. Without changing the recording method typical of conventional holography, it is possible to get images of objects with different characteristics of space-time field coherence. In the imaging facility, laser emission is sent through a telescopic system and a rotating opal glass to the object transparency. The interferometer consists of a beam splitter that divides the field scattered by the object into two channels, one containing an attenuator to get the necessary beam ratio when producing the transparency, and the other containing a lens, point diaphragm and collimator. The beams in the two channels are combined in the registration plane. Experimental results show that the proposed method can be used to reconstruct images of both spatially coherent and incoherent sources in a single functional arrangement. Thus it should be useful in space research, radio astronomy and other fields where the coherence properties of the received field are either a priori unknown or vary over wide limits. Figures 3, references 7; 4 Russian, 3 Western,  
I144-6610]

UDC 535.345.6:535.317.1

USING DIGITAL HOLOGRAPHIC FILTERS TO OPTIMIZE METHODS OF COHERENT-OPTICS  
PATTERN RECOGNITION: THEORY AND COMPUTER SIMULATION

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 52, No 3, Mar 82  
(manuscript received 28 Jul 80) pp 533-538

GIRNYK, V. I., KURASHOV, V. N. and NAKHODKIN, N. G.

[Abstract] The authors consider application of some theoretical models of synthesizing optimum sets of criteria to the problem of optical pattern recognition using digital holographic filters. A numerical analysis is done on the structure of correlation responses resulting from such filtration in analysis of a test set of objects. It is shown that methods involving isolation of major components or single factors of a given set of objects can give a recognition system considerable advantages over matched filtration. Digital holography is proposed as a method of forming the filters that realize the necessary algorithm. Two such methods are considered in which the object is recognized by a binary sequence of correlation responses. The recognition process is computer-simulated, and an analysis is made of errors that arise with consideration of the finite region of averaging of the correlation response. In a future paper, experimental results will be given that demonstrate the practical feasibility of detectors based on the proposed principles. Figures 2, references 8; 6 Russian, 2 Western.

[144-6610]

UDC 517:518.948+530.145

SOLUTION FOR PROBLEM OF IMAGE RECONSTRUCTION IN NMR TOMOGRAPHY

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 263, No 4, Apr 82  
(manuscript received 24 Nov 81) pp 872-877

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TIMONOV, A. A., Institute of Applied Mathematics imeni M. V. Keldysh,  
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[Abstract] One new method of internal inspection is based on using the effect of nuclear magnetic resonance and computer-assisted tomography. A major problem that arises in application of this technique involves determining the distribution function of atomic nuclei with respect to the integrals of the function on several sets. The authors describe a general approach to solution of the imaging problem in NMR tomography based on methods of solving incorrectly stated problems, enabling compilation of stable computer algorithms that reconstruct images of the internal structure of objects with quality adequate for practical purposes. The analysis is based on dividing the process of tomographic imaging into four stages: 1. tomographic

measurements; 2. discretization of analog signals and conversion to digital form; 3. reconstruction of the distribution law for atomic nuclei that interact with the resultant magnetic field and that are situated in a given cross section of the object; 4. representation of this law in a form convenient for imaging. Expressions are given for the formalized description of this sequence, and specific aspects of application of the solution to computer-assisted tomography are considered. In addition to nuclear magnetic resonance, the proposed approach is applicable to x-ray, ultrasonic, microwave and other forms of computer-assisted tomography. References 7: 3 Russian, 4 Western.

[147-6610]

## PLASMA PHYSICS

### SUPERDETONATION TRAVEL OF PLASMA FRONT AGAINST INTENSE LASER BEAM

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 82, No 3, Mar 82 (manuscript received 8 Oct 81) pp 740-746

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University imeni I. I. Mechnikov

[Abstract] In continuation of a study of fast ionization waves attending the travel of a plasma front against an intense laser beam, theoretical calculations are presented that generally agree with experimental results pertaining to conditions of a hyperlinear strong dependence of the plasma front velocity on the laser radiation intensity. Taken into account are finite duration of the laser pulse, the transient period of wave buildup, and threshold laser radiation intensity. At prebreakdown intensities the energy distribution of electrons is assumed to be maxwellian. A mechanism of plasma front movement is established on this basis that explains earlier experimental results on fast ionization waves in argon or xenon with radiation from a CO<sub>2</sub> laser. The authors thank S. I. Anisimov and P. P. Pashinin for helpful discussions, also M. Ya. Amus'ya for supplying experimental data on photoionization cross section. Figures 2, references 14: 12 Russian, 2 Western.

[154-2415]

### GENERATION OF MAGNETIC FIELD BY CHARGED PARTICLE FLUXES AND DECELERATION OF PARTICLES IN PLASMA

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI  
in Russian Vol 35, No 2, 20 Jan 82 (manuscript received 6 Dec 81) pp 72-74

RUDAKOV, L. I., Institute of Atomic Energy imeni I. V. Kurchatov

[Abstract] The effects of excitation of conduction currents in a medium upon injection of particle fluxes into it were investigated with respect to laser and cosmic plasmas. The phenomenon is manifested in generation of a magnetic field and additional deceleration of fluxes. A series of equations is derived to explain the injection of an intense relativistic electron beam into an electrically conductive medium. Epithermal fast electrons occurring as a

result of collective effects in the subcritical range of the plasma corona play an important role in a plasma created by powerful lasers at output of  $10^{13} \text{ W/cm}^2$  and above. The integral fluxes in a cosmic plasma are high despite very low density. It is important to take into account the effects of excitation of compensating currents of conductivity in a medium when particle fluxes are injected to it that exceed the Alfvén limit, both of which occur in laser and cosmic plasmas. References 5: 3 Russian,

2 Western.

[107-6521]

STRESS, STRAIN AND DEFORMATION

UDC 534.222.2

ENERGY DISSIPATION AND EFFECT OF MELTING ON IMPACT COMPRESSION OF POROUS BODIES

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian  
No 1 (131), Jan-Feb 82 (manuscript received 29 Oct 80) pp 131-142

DUNIN, S. Z. and SURKOV, V. V., Moscow

[Abstract] Impact compression of porous solid bodies by shock waves is considered, the amplitude of these waves being small in comparison with the compressibility of the material but sufficiently large to produce viscoelastic flow in the vicinity of pores. The behavior of such a body is analyzed on the basis of equations of motion according to a model of spherical cells, assuming negligible gas content in pores, and equations of energy dissipation in Lagrangian variables. An adiabatic process is assumed in the porous body, the effect of heating is included, and shock waves with intensity sufficiently high to produce a local melting zone are considered. In the latter case, with coexistence of two phases, the problem reduces to a system of two equations, differential and integral, for the volume fraction of molten substance and the strain rate or longitudinal porosity gradient as functions of porosity. Energy is found to accumulate and dissipate most intensely at pore surfaces. There is a critical porosity of the material and a critical pressure amplitude of shock waves at which melting begins. The trend of shock adiabats, especially within the range of pressures corresponding to complete collapse of pores or strength of the material, depends on initial porosity. In the case of materials with high initial porosity they have a cusp, which is an indicator of anomalous behavior. These conclusions are based on theoretical analysis, no experimental evidence of anomalous behavior caused by melting under impact compression by shock waves is yet available. Figures 6, references 12: 11 Russian, 1 Western.

[159-2415]

## THERMODYNAMICS

UDC 535.21

### INFLUENCE OF HEAT CONDUCTION EFFECTS ON OXIDATION KINETICS AND HEATING DYNAMICS OF METALS IN AIR WHEN EXPOSED TO RADIATION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 263, No 5, Apr 82  
(manuscript received 4 Nov 81) pp 1115-1118

BUZYKIN, O. G., BURMISTROV, A. V., KLYUKIN, S. S., KOGAN, M. N. and US'KOV, V. M.

[Abstract] Previous research has shown that laser heating of oxidizable metals is considerably influenced by surface temperature inhomogeneities caused by heat conduction or nonuniform distribution of radiation intensity and initial thickness of the oxide film. It has been assumed heretofore that the oxide film itself is uniformly heated with respect to thickness. However, the authors demonstrate in this paper that occasions arise where temperature gradients in the oxide cannot be disregarded. At emission intensities of the order of  $1 \text{ kW/cm}^2$  or more, local oxidation becomes appreciably dependent on the temperature distribution through the oxide layer, and as a result heat conduction effects have a direct influence on the kinetics of the chemical reaction. An investigation is made of this factor and the part that it plays in laser heating dynamics. The analysis is restricted to the case of continuous irradiation with a focal spot considerably greater than film thickness, disregarding longitudinal gradients in the oxide, and assuming that the layer is plane-parallel in describing processes of heat and mass transfer through the oxide. Specific examples are given of numerical calculations illustrating the way that specific features of oxidation kinetics influence dynamics of laser heating of metals in air at atmospheric pressure. It is found that the specifics of laser heating in conjunction with low heat conduction of oxide give rise to nonisothermal conditions of transfer of reaction components through the oxide layer. As a result, the rate of oxidation is directly dependent on the local intensity of the radiation. This is especially pronounced for pulse-periodic laser operation. Figures 2, references 11: 10 Russian, 1 Western.

[146-6610]

MATHEMATICS

UDC 518.733.431

PURSUIT PROBLEM FOR CLASS OF LINEAR DIFFERENTIAL GAMES

Tashkent IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: SERIYA FIZIKO-MATEMATICHESKIKH NAUK in Russian No 1, Jan-Feb 82  
(manuscript received 3 Apr 80) pp 20-23

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[Abstract] A linear differential problem  $\dot{z} = Cz - u + v$  is considered ( $z \in \mathbb{R}^n$ ,  $\mathbb{R}^n$  is an  $n$ -dimensional Euclidean space with a compact subset  $P$  and an arbitrary nonempty subset  $Q$ ,  $C$  is a constant matrix,  $u \in P$  and  $v \in Q$  are control parameters from  $\mathbb{R}^n$ ). The terminal set is  $M = M_0 + M_1$  ( $M_0$ — linear subspace of space  $\mathbb{R}^n$  and  $M_1$ — nonempty closed convex subset of the subspace of the  $L$ -orthogonal complement to  $M_0$  in  $\mathbb{R}^n$ ). With the aid of the operator of orthogonal projection from  $\mathbb{R}^n$  onto  $L$ , a theorem is proved that establishes from which points  $z_0$  pursuit can end with capture within a given time period  $\tau_0$ . The implication of this theorem is illustrated on the "boy and crocodile" problem with a numerical example. References 3 Russian.  
[165-2415]

UDC 519.21

LIMIT THEOREM FOR BRANCHING MARKOV PROCESSES WITH IMMIGRATION IN TRANSIENT MODE

Tashkent IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: SERIYA FIZIKO-MATEMATICHESKIKH NAUK in Russian No 1, Jan-Feb 82  
(manuscript received 19 Feb 80) pp 8-12

BADALBAYEV, I. S., Institute of Mathematics imeni V. I. Romanovskiy, UzSSR Academy of Sciences

[Abstract] A branching process is considered where each particle of one kind at a given instant  $t$  converts to  $k$  particles within time interval

$\Delta t \rightarrow 0$  with probability  $\delta_{k1} + p_k \Delta t + O(\Delta t)$ , independently of the origin and the age as well as the destiny of other particles. Moreover, independently of the number of particles, at this instant  $t$  there appear (immigrate)  $k$  particles within time interval  $\Delta t \rightarrow 0$ , with probability  $\delta_{k0} + q_k(t) \Delta t + O(\Delta t)$ , and they convert just as the others. A limit theorem (time  $T \rightarrow \infty$ ) for this process is proved on the basis of another theorem describing such a process and four corollaries, assuming that the immigration rate can vary during the period  $T$ . References 1 Russian.

[165-2415]

UDC 518.0

#### NEW METHOD FOR NUMERICAL MODELING OF COMPLEX DISCRETE SYSTEMS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 263, No 4, Apr 82  
(manuscript received 3 Dec 81) pp 820-824

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[Abstract] A new approach is proposed to analysis of the evolution of complex discrete systems made up of a large number of interacting elements. This approach has been the basis of the technique called the method of virtual contacts that has been put to direct use in studying coagulation processes of a certain type. However, it has been suggested that the method has extensive possibilities going far beyond the scope of these studies. The authors study the evolution of a complex discrete system made up of a large number of components that are in mutual contact. There is a given matrix of parameters that uniquely defines noncontact evolution of the components as well as their properties. Processes are considered in which only binary contacts occur, and it is assumed that the condition corresponding to such contact is given. This condition is then treated as an equation for finding the instant of contact. The so-called limiting model of the process is considered where each contact concludes with coagulation of the components. The approach was used to do numerical experiments on formation of planetary systems in a new cosmogonic model. References 4: 3 Russian, 1 Western,  
[147-6610]

CSO: 1862

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